



# **Stormwater Drainage Conveyance Systems (Non-BMP related)**

## **General Design and Construction Guidelines**

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*(Note: Chapter 19 Subdivisions, Section 19-27 and Chapter 24 Zoning, Article III Site Plans, Section 24-145 of the Code of James City County require the adequate control of stormwater drainage and erosion and sedimentation, whether temporary or permanent, and the submission of a drainage plan showing the proposed drainage system including all open channels, closed storm drain pipes and stormwater management facilities proposed to convey drainage, including the size of all pipes and channels, types of pipes and linings, drainage calculations and related construction details. In addition, Minimum Standard #19 of the Virginia Erosion and Sediment Control Regulations requires adequate man-made channels, pipes and storm sewer systems by analyses using the 10-year storm. The conditions of County VSMP Ordinance, Chapter 8 Article II of the County Code also apply.)*

## **1.0 Introduction and Purpose**

The following are basic guidelines and principles for the design and construction of private stormwater conveyance systems within James City County (JCC) which are not located within Virginia Department of Transportation (VDOT) Right-of-Way and are not interior to a stormwater management/best management practice (BMP) facility. Storm drainage systems are typically provided for urban land development projects to collect and convey onsite stormwater runoff or divert upstream (offsite) stormwater runoff through or to a site to an acceptable downstream stormwater management facility. Systems may include overland sheet flow, concentrated flow, paved street flow, curb and gutter flow, inlets, storm drains (sewers), open channels, culverts or enclosures and special structures such as diverters, manholes, junction boxes and energy dissipators.

The purpose of these guidelines is to provide the owner, applicant or its designated representative with general design and construction guidance for preparing drainage plans as required for subdivision and/or site development plan submissions and to subsequently assist the James City County Engineering and Resource Protection Division in the formal review of such plans. The goal of the guidelines is to establish minimum design and construction standards for stormwater drainage conveyance systems to minimize potential adverse effects of such systems on the environment, upstream/downstream properties or structures or downstream stormwater management facilities in accordance with strategies presented in the applicable state laws and regulations, County Code, the Virginia BMP Clearinghouse website, the Virginia Stormwater Management Handbook (manual) and to attempt to expedite the review process by requiring consistent plan information.

The James City County Division of Engineering and Resource Protection is designated as the local VESCP/VSMP authority. This document was revised administratively by the VESCP/VSMP authority due to implementation of the Virginia Stormwater Management Program.

## **2.0 General Design Criteria**

- 2.1. These guidelines pertain to site drainage systems defined as **“private”** type gravity systems or elements which are located **outside Virginia Department of Transportation (VDOT) road rights-of-way**. All stormwater drainage systems located within VDOT road rights-of-way or included for maintenance under the state Secondary Road System shall be designed in accordance with current VDOT standards, specifications and drainage manual requirements.

VDOT is responsible for the review and approval of design plans for these systems; however, the County will review and comment on design plans where function of the road drainage system may impact a downstream site, site drainage system or an approved stormwater management/ BMP structure.

- 2.2. Drainage improvements, outside VDOT road rights-of-way, shall be designed and constructed to conform with current VDOT standards and specifications, if criteria are not otherwise established within these design and construction guidelines.

- 2.3. If provisions of these guidelines conflict with current versions of the Code of the County of James City, Virginia or other state or federal regulations; then provisions or requirements of the ordinances or regulations shall supersede these guidelines.
- 2.4. Proposed drainage methods such as use of natural streams or swales or constructed channels, storm drain systems, etc. shall be consistent with any previously approved comprehensive, concept, master, rezoning, preliminary or final site plans, as applicable, within James City County or other related local or state jurisdictions.
- 2.5. Concentrated stormwater runoff leaving a development site via a site drainage system shall be conveyed and discharged to a well-defined, adequate natural or man-made receiving channel, drainage system or stormwater management/BMP facility. Adequacy computations and design of downstream channels and pipe improvements for uncontrolled (bypass) areas shall be performed in accordance with Virginia Erosion and Sediment Control Regulations and Minimum Standard # 19 of the Virginia Erosion and Sediment Control Handbook (VESCH) and/or in accordance with quantity and flood control requirements of the Chapter 8, Erosion and Sediment Control and Virginia Stormwater Management Program ordinance of James City County.
- 2.6. Drainage systems shall be designed in a manner to not create an adverse or increased impounding effect on upslope adjacent property or structures; or an adverse or erosion, sediment or flooding impact on adjacent downstream property or structures. Drainage easements may be necessary.
- 2.7. Drainage systems shall be designed to minimize impacts to environmentally sensitive areas to the greatest extent possible. Environmentally sensitive areas include, but are not limited to: wetlands, hydric soils, floodplains, resource protection areas (RPA's), resource management areas (RMA's), steep slope areas, highly erodible or permeable soils, potentially significant archaeological or historical areas, wildlife habitats, shoreline or tidal influence areas, conservation open spaces or densely vegetated, mature forested or prime agricultural farmland.
- 2.8. All drainage systems shall be designed and sized based on anticipated ultimate development conditions for the project, including future upstream connecting phases and offsite tributary areas, if applicable.
- 2.9. Drainage systems shall be designed to convey stormwater runoff from onsite, offsite or a combination of these sources.
- 2.10. Normal depths of existing waterways, design water surface elevations (pools) of downstream impoundments or stormwater management/BMP facilities or other existing or pending drainage systems shall be considered in the hydraulic design of onsite storm drainage systems (ie. tailwater conditions).
- 2.11. Proposed site and lot grading and drainage pattern changes shall be considered when planning or configuring the proposed drainage system for the development site.
- 2.12. An adequate or safe overflow path shall be provided should the drainage system become blocked, non-functional or if the system's design storm is exceeded. Overflow paths should not directly impact or create unsafe conditions at any existing or proposed structure, road, travelway or walkway. Ponding depths, headwater/backwater effects or water surface elevations may be required to be shown on the plans to properly assess impacts on upslope adjacent areas, whether onsite or offsite, and existing or proposed structures.
- 2.13. Drainage systems shall be designed to honor existing drainage divides to the greatest extent possible. Concentrated surface flow shall not be "diverted" to adjoining properties unless the receiving offsite natural channel or man-made system is adequate for capacity and velocity and proper notification and permission is obtained from the adjoining owner.

- 2.14. Temporary erosion and sediment controls (E&SC) shall be installed prior to construction of the proposed stormwater drainage conveyance system. Temporary stormwater management or erosion and sediment control measures may be required to manage higher discharges rates and volumes that may be associated with runoff from mass-disturbed construction sites than that which may be anticipated during pre-developed or final post-developed, stabilized and landscaped conditions.
- 2.15. Hydrology and Hydraulics. All hydrologic and hydraulic computation methods as outlined in the current edition of the VDOT Drainage Manual or any other standard accepted reference for the design of stormwater drainage systems for urban or transportation facilities are acceptable for use.
- 2.16. Hydrology. In general, use of the Rational Method will be limited to drainage system designs (non-BMP related) where the total contributing drainage area is less than 20 acres for typical commercial, business, office or similar site development activities and 50 acres for larger typical residential or mixed-use type projects. For projects greater than 50 acres or “non-typical” type development projects, the Engineering and Resource Protection Division should be notified in advance if the rational method is to be utilized for site drainage system design. Standard engineering references are acceptable for selection of runoff coefficients and methods to compute times of concentration. Use of traditionally accepted local (James City County or equivalent) rainfall-intensity-frequency data (I, inches per hour) based on the determined time of concentration is required.
- 2.17. Hydrology. In general, Soil Conservation Service (SCS) based hydrologic methods are encouraged for all project types and sizes and shall be used for drainage systems greater than 20 acres for typical commercial, business, office or similar site developments and 50 acres for larger typical residential or mixed-use type projects. SCS hydrology methods generally consist of any soil-cover-complex based methodology which utilizes hydrologic soils group classifications (A, B, C, or D) and runoff curve numbers (CN’s) based on land use. Acceptable methods may include Technical Release Number 20 (TR-20), Technical Release Number 55 (TR-55), the U.S. Army Corp. of Engineers HEC-1 Flood Hydrograph Package and/or any other commercially available similar developed program which is based on SCS methodology. Use of traditionally accepted local (James City County or equivalent) 24-hour rainfall values (P, inches) are required.
- 2.18. Computer Program Assistance. Use of standard, accepted and commercially available computer software or programs are strongly encouraged to assist with performing hydrologic and hydraulic computations associated with the design of stormwater drainage conveyance systems. Various computer programs are widely available and simplify the process to analyze, design and perform multiple computations associated with design such as weighted runoff coefficients or curve numbers, times of concentration, peak design discharges, storm drain (sewer) and inlet computations, culvert headwater or backwater, flow depth, hydraulic grade line computations and open channel analyses. Software or program documentation may be requested.
- 2.19. Presentation. In addition to the preparation of construction plans, proper and clear presentation of input, output and graphical data associated with the use of computer programs is essential for expeditious review and approval of drainage plans. In order to not clutter construction plans with computational data associated with hydrology and hydraulics, results can be presented by use of a supplemental drainage design report in a bound 8-1/2 x 11 inch size format. The design report shall generally include, but is not limited to a cover sheet with title and date; project name, owner and preparer information; a brief narrative summarizing the types of drainage facilities to be utilized for the project; methodology and programs used; a summary of results; and individual computations, as needed. Construction data and details necessary for installation of the systems shall be provided on the construction plans; however, all computational data in the design report should closely match construction plan information.

- 2.20. Maintenance Agreement. Depending on the project type and drainage facilities proposed, a standard Inspection / Maintenance agreement, executed between the Owner and the County may be required for onsite drainage systems. The agreement provides for future right-of-entry and defines maintenance responsibilities. The agreement does not pertain to any elements located within any VDOT rights-of-way.
- 2.21. Asbuilts and construction certifications, including an internal closed-circuit camera television (CCTV) inspection performed by the operator, are required for all stormwater conveyance channel systems, in accordance with Chapter 8 ordinance and standards and specifications developed by the VESCP/VSMP authority.
- 2.22. At the discretion of the VESCP/VSMP authority administrator, stormwater pipe drainage systems less than 12-inch diameter in size are considered yard-type systems, not primary drainage infrastructure systems, and are not subject to the County's stormwater facility pipe inspection fee program.
- 2.23. At the discretion of the VESCP/VSMP authority administrator, stormwater pipe drainage systems less than 15-inch diameter in size are considered yard-type systems, not primary drainage infrastructure systems, and are not subject to the County's internal closed-circuit television (CCTV) requirements as part of the asbuilt/construction certification program.
- 2.24. The VESCP/VSMP authority reserves the right to formally request or comment on any information relative to the design or construction of stormwater drainage conveyance systems in addition to that shown within these guidelines. Additional information may include, but is not limited to field investigations, mapping; surveying; plans, profiles or details; soil or water pH testing; soil borings and testing; compaction test reports; hydraulic or structural designs or computations; shop drawings; specifications and product material literature.
- 2.25. These guidelines typically apply to stormwater drainage conveyance systems which are non-BMP related such as inlets, storm drains, culverts and open channels. For stormwater management / best management practice (BMP) design and construction guidance, refer to current versions of the Virginia BMP clearinghouse website, the revised *Virginia Stormwater Management Handbook* (manual); Chapter 8 (Erosion and Sediment Control and Virginia Stormwater Management Program) and Chapter 23, Chesapeake Bay Preservation ordinances of the Code of James City County, Virginia; and the Virginia Erosion and Sediment Control Handbook (VESCH).

### **3.0 Open Channel Design**

- 3.1. Stormwater conveyance channels, not intended for use as a dry swale BMP, shall be designed to convey the peak discharge from a 10-year design storm event without overtopping the channel's normal banks. Larger permanent conveyance channels in easily accessible or high-use locations such as residential areas, parking lots, recreational parks, etc. may be required to have freeboard of at least 0.5 feet.
- 3.2. Stormwater conveyance channels, not intended for use as a dry swale BMP, shall be designed so that the velocity from peak discharges associated with a 2-year design storm shall not exceed the permissible velocity for the type of channel lining used.
- 3.3. Mannings equation shall be used to analyze, design or size the channel. Refer to standard engineering references such as the Virginia Erosion and Sediment Control Manual or HEC-15 for use of the Mannings equation and selection of a Mannings "n" value for channel linings or bare earth conditions. Although "n" values typically vary with flow depth, values for typical, local projects will generally range around 0.020 to 0.025 for sparsely vegetated channels; 0.030 to 0.040 for grass or natural channels, 0.05 for erosion control matted channels, 0.015 for paved linings and around 0.050 to 0.070 for riprap linings.

- 3.4. Channel linings shall be analyzed, designed and selected using procedures in the current edition of the Virginia Erosion and Sediment Control Handbook.
- 3.5. Design of riprap channels shall be analyzed and designed in accordance with the current edition of the Virginia Erosion and Sediment Control Handbook.
- 3.6. A cross-section or detail with channel design and construction data shall be provided on the construction plan for each open channel or segment, as applicable, for the drainage system. At a minimum, channel data shall include label, general location, shape or type, bottom width, top width, geotextile fabric, lining type and depth, slope, length, side slope and constructed depth. Pertinent design data should also be provided including the selected Mannings “n” value, drainage area, time of concentration, runoff coefficient or curve number, intensity, peak discharge, velocity and normal water depths for the 2-and 10-year design storm events, as applicable. The channel label shall match between the plan view and the channel detail.
- 3.7. Channel side slopes shall be 3H:1V or flatter. Slopes steeper than 3H:1V may be required to use erosion control blankets to aid in the establishment of vegetative cover. No channel side slopes should be steeper than 2H:1V, unless specific and adequate designs are presented.
- 3.8. Low flow sections are recommended in the design of channels with large cross-section.
- 3.9. Use of rock or timber check dams similar to that required for Open Channel BMP Systems or other enhanced, pervious-type erosion resistant lining systems such as turf reinforcement mats (TRM’s) are encouraged in non-critical areas to promote water quality and if ponding will not create a nuisance, hazard or undesirable condition.

#### **4.0 Storm Drain and Inlet Design**

- 4.1. All storm drains (sewers) shall be designed to convey the peak discharge from a 10-year design storm event. Design for larger storm events may be necessary if buildings or structures may be impacted.
- 4.2. Storm drains shall generally be designed as gravity flow, non-pressurized systems such that flow depth is less than the height of the conduit. Pressure flow systems, where pressure head is above the top of the conduit but less than inlet rim (top) elevations, are generally acceptable. Pressure flow systems, which may surcharge above inlet rim (top) elevations are generally not acceptable; however, may be allowed on a case-by-case basis depending on intended uses at the site and with proper coordination with the VESCP/VSMP authority. For all cases, hydraulic grade line computations are required.
- 4.3. Storm drain pipe shall be circular shaped. Use of galvanized Corrugated Metal Pipe (CMP) is not allowed without special permission. Allowable material types for new storm drains shall include: Reinforced Concrete Pipe; Corrugated Steel Fully Asphalt Coated and Fully Paved; Corrugated Steel Fully Asphalt Coated and Fully Concrete Lined; Steel or Aluminum Smooth Wall Spiral Rib Pipe; High Density Corrugated Polyethylene Smooth Interior Pipe; and Polyvinyl Chloride Ribbed or Corrugated Smooth Interior Pipe. These materials are subject to current applicable standards and specifications of VDOT for material, manufacture, transportation and handling.



- 4.4. Use of smooth interior, corrugated high density polyethylene pipe HDPE pipe is allowed but must follow proper manufacturer and pipe industry standards for flexible pipe design and installation including bedding, backfill, load and soil design. Appropriate reference to VDOT Road and Bridge Standards or specifications for pipe type and installation must be provided as intended use. If VDOT standards are not referenced, provide a typical bedding and installation detail; indicate type of pipe and minimum cover requirements during construction and allowable maximum height of final and temporary cover for the type of pipe selected. Use of corrugated smooth interior high density polyethylene pipe for private-drainage systems should have proper reference on the construction plan for pipe type (AASHTO M252, AASHTO M294, ASTM F667, etc.), bedding and installation in accordance with association standards (ASTM D2321, etc.) and for connection type to concrete manholes structures or inlets (ASTM C923, etc.)
- 4.5. Other material types and shapes not specifically mentioned herein and not subject to VDOT jurisdiction may be allowable subject to advance notification and approval by the VESCP/VSMP authority. Alternate pipe materials shall have durability, structural and hydraulic properties comparable to reinforced concrete pipe. Sufficient manufacturer documentation may be required for design review as well as sufficient notes, specifications and details on the construction plans to ensure proper installation and construction. Pipe applicability shall be subject to manufacturer recommendations for height of cover, permissible velocity, corrosive resistance, pH of soil, pH of water and any historical records for corrosive resistance of similar pipe materials used in the service area.
- 4.6. Storm drain sizes shall be determined by use of Mannings Equation. Refer to standard references such as the VDOT Drainage Manual and/or the Virginia Erosion and Sediment Control Manual for use of the Mannings equation and selection of a Mannings “n” value for storm drain design. Typical Mannings “n” values for new, allowable pipe types include 0.013 for Reinforced Concrete Pipe; 0.013 for Corrugated Steel Fully Asphalt Coated and Fully Paved; 0.013 for Corrugated Steel Fully Asphalt Coated and Fully Concrete Lined; 0.014 for Steel or Aluminum Smooth Wall Spiral Rib Pipe; 0.012 for High Density Corrugated Polyethylene Smooth Interior Pipe; and 0.011 for Polyvinyl Chloride Ribbed or Corrugated Smooth Interior Pipe.
- 4.7. Hydrologic or hydraulic analyses of existing, old storm drainage pipes shall use Mannings “n” values of 0.013 for reinforced concrete pipe and 0.024 for any corrugated metal pipe regardless of lining or corrugation type.
- 4.8. Storm drain pipe, bedding, backfill and compaction requirements shall be provided on the plans or referenced to appropriate VDOT Road and Bridge specifications.
- 4.9. A profile view of the storm drain system(s) is strongly encouraged, but not required. Profiles shall show proper design and construction information, cover, potential utility conflicts and existing, interim (if applicable) and proposed grades. If storm drain (sewer) profiles are not to be provided within the project plan set, it is the design professional’s responsibility to ensure that minimum cover is maintained, pipe wall thicknesses are adequate for anticipated maximum heights of cover for each storm drain segment, and no apparent conflicts with other site utilities are present. Clearly indicate all pipe types, thickness class, size, lengths and slope on the plan drawings, if no profiles are provided.
- 4.10. Minimum cover over storm drains shall not be less than one (1) foot, except at outfall locations. Maximum heights of cover shall not exceed VDOT or manufacturers recommendations for strength, class, thickness or size selected. Adequate temporary protection or cover shall be provided during construction operations to prevent wall crushing and non-uniform deflection.
- 4.11. Use of a structure and storm drain pipe schedule can be used on the construction plan set to show important storm drain and inlet construction information and to expedite the review process.

- 4.12. Storm drain hydraulic grade line computations (HGL) shall be provided for all gravity and pressure flow systems. The HGL shall be computed and presented using methods set forth in the VDOT Drainage Manual or other standard accepted computational spreadsheet, table or form. HGL computations and results should be attached in the supplemental drainage design report for the project and presented in a clear and easy to follow format. HGL presentation in graphical format on storm drain profiles, if provided, is acceptable.
- 4.13. Minimum storm drain pipe diameter is 15 inches. Twelve (12) inch diameter may be accepted if pipe segment(s) are hydraulically adequate and will function properly. Generally, distances between 12 inch storm drain segments are limited to 50 feet or less.
- 4.14. Velocity of storm drains shall not be less than around 2.0 feet per second based on design full or partial flow conditions. Maximum culvert velocity shall be limited by the permissible velocity of the pipe material and outfall conditions. In general, storm drain interior velocities should not exceed 10 to 15 feet per second to prevent scour or loss of lining.
- 4.15. No reductions in pipe size are allowed in the downstream direction of flow.
- 4.16. A minimum of one (1) foot vertical and five (5) feet horizontal clearance shall be provided between storm drains and underground utilities except for public water mains. For water mains or service lines, the minimum horizontal separation is ten (10) feet or as required by the governing jurisdiction (JCSA, etc.).
- 4.17. Storm drain slopes exceeding twenty (20) percent shall require anchors to prevent sliding of the pipe and a trench cut-off wall near the outfall to prevent piping of bedding material.
- 4.18. The ends, entry or exit of a storm drain system shall be provided with standard headwalls, endwalls, curb inlets, yard inlets, flared end sections or other appurtenances suitable for the intended storm drain system. Materials shall be consistent with the host storm pipe material and shall include any boots, grouting, collars, connections, etc. to ensure water tightness.
- 4.19. For maintenance purposes inlets, access structures (inlets, manholes, etc.) are required where two or more storm drains converge; where pipes change size; where a change in horizontal alignment occurs; and where a change in design grade occurs. The maximum length between access structures is 300 feet for pipes 24 inch or less; 400 feet for pipes between 24 and 36 inch; and 800 feet for pipes 36 inch and larger. Allowable spacing between access structures may be adjusted due to unusual site conditions or constraints with advance notification to the Engineering and Resource Protection Division. Curved alignments may be considered on a case-by-case basis with proper notification to the VESCP/VSMP authority and if based on sound pipe material manufacturer Association design standards and the joint deflections do not exceed established allowables.
- 4.20. Stormwater inlets shall be designed in accordance with hydraulic methods and procedures in the VDOT Drainage Manual or other standard accepted computational spreadsheet, table or form. Inlet sizing computations should be attached in the supplemental drainage design report for the project and presented in clear and easy to follow format.
- 4.21. Design plans shall specify the intended inlet and grate type, bar spacings (if applicable), top or rim elevation and invert elevation(s) as applicable. In urban, pedestrian accessible areas, grate type and bar spacing shall be selected based on safety considerations and specified on the construction plans and associated drainage report computations.



- 4.22. Yard inlets shall be designed for the 10-year design storm event and evaluated for the 100-year (check) storm. Adjacent properties or existing or proposed structures, buildings, walkways, etc. shall not be subject to water ponding. In general, siting and elevations of existing or proposed commercial or residential structures or lot grading shall be such that no flooding shall result from inlet ponding, backwater or overflow of inlet or pipe systems during the design or check storm event.
- 4.23. A minimum drop of 0.10 feet (1.2 inches) in invert is suggested at access structures.
- 4.24. Inlet shaping in accordance with VDOT Standard IS-1 is required within all access structures.
- 4.25. Steps in accordance with VDOT Standard ST-1 are required in all access structures exceeding four (4) feet in depth. Intermediate safety landings in accordance with VDOT Standard SL-1 may be required for excessively deep access structures.
- 4.26. Any modification or variance from standard VDOT drainage structures shall include sufficient notes, details, specifications and certification by the design professional on the plan to ensure proper construction.

### **5.0 Culvert Design**

- 5.1. Culverts for private roads, not to be included in the VDOT Secondary Road System, shall be designed for the 10-year storm event. Designs for higher frequency storm events (ie. 25-year, 50-year, 100-year) may be required, if formally requested by the County, for certain circumstances which involve protection of the public's health, safety or welfare or for areas with special flooding or drainage concerns.
- 5.2. In general, culverts lengths are limited to 100 feet or less of total length from the toe of fill to toe of fill. For construction purposes, designs should attempt to match proposed pipe length to standard available even pipe material lengths or nearest one-foot increments, to the greatest extent possible.
- 5.3. Culverts shall be designed for the 10-year design storm and evaluated for the check 100-year design storm events under inlet and outlet control conditions. Headwater (HW) elevation shall be determined using methods in the current edition of the Federal Highway Administration, Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts and the VDOT Drainage Manual, as applicable.
- 5.4. Culverts shall be sized so the HW elevation for the 10-year design storm event shall not exceed an elevation eighteen (18) inches below the edge of shoulder of the roadway.
- 5.5. Culverts shall be designed so the HW is within a range of 1.0 to 1.5 times the inside vertical dimension of the pipe (ie. HW/D between 1.0 and 1.5 with 1.2 ideal). Adequate consideration will be given to minimum pipe size and velocity requirements, which may affect these criteria.
- 5.6. Minimum culvert velocity is two (2) feet per second based on design flow conditions. Maximum culvert velocity shall be limited by the permissible velocity of the pipe material and outfall conditions. In general, pipe interior velocities should not exceed 10 to 15 feet per second to prevent scour or loss of lining.
- 5.7. A profile view of each culvert is strongly encouraged, but not required. The profile view shall show critical design information such peak design discharge, drainage area, time of concentration, runoff coefficient or curve number, water surface elevations and related construction data such as structure number, pipe size, slope, length, invert elevations, existing and proposed grade, end sections or headwalls, incidental channel grading and outlet protection requirements. However, standard headwater charts, data sheets and design computations are still required in the drainage report.

- 5.8. The headwater elevation for the 100-year design storm event shall not result in any upstream flooding building structures. Generally, the 100-year (check) storm return period must be checked to ensure conveyance without causing significant damage to the roadway, stream or adjacent property and to ascertain the effects of the culvert on any base flood elevations and to permit adequate passage of emergency vehicles if required during a flooding condition.
- 5.9. Culvert bedding, backfill and compaction requirements shall be provided on the plans or referenced to appropriate VDOT Road and Bridge specifications and manufacturers or industry standard recommendations.
- 5.10. Standard headwalls, endwalls or flared end sections shall be provided on culverts in accordance with VDOT requirements and standards; or otherwise in accordance with the following: Standard endwalls or end sections, matching the host pipe material, shall be provided on all culverts except 12 inch and 15 inch diameter pipe culverts under driveways. For culverts 12 to 24 inch diameter, a flared end section shall be used unless the height of fill and side slope exceeds 10 feet or 2H:1V, respectively, in which case a standard headwall should be used. For culverts 24 to 36 inch diameter, either a flared end section or headwall shall be used. A flared end section is acceptable if fills are 10 feet or less, HW/D is less than 1.5, inflow is less than 50 c.f.s. and installation of a headwall would constitute a safety hazard. For culverts exceeding 36 inch diameter, a standard headwall shall be provided unless a safety hazard is present, in which case a flared end section should be considered.
- 5.11. Culverts shall be arch, box, circular, elliptical or oval-shaped. Use of reinforced concrete pipe is fully encouraged for standard culvert applications. Other culvert materials will be considered subject to advance notification and approval by the Engineering and Resource Protection Division. Alternate pipe materials shall have durability, structural and hydraulic properties compared to reinforced concrete pipe. Sufficient manufacturer documentation may be required for review as well as sufficient notes, specifications and details on the construction plans to ensure proper installation and construction. Alternate material may include, but are not limited to Corrugated Steel Fully Asphalt Coated and Fully Paved; Corrugated Steel Fully Asphalt Coated and Fully Concrete Lined; Steel or Aluminum Smooth Wall Spiral Rib Pipe; High Density Corrugated Polyethylene Smooth Interior Pipe; and Polyvinyl Chloride Ribbed or Corrugated Smooth Interior Pipe. Use of these materials is also subject to current applicable standards and specifications of VDOT and the manufacturer for material, manufacture, transportation and handling. Pipe applicability shall be subject to established VDOT and manufacturer design criteria for height of cover, permissible velocity, corrosive resistance, pH of soil, pH of water and any historical records for corrosive resistance of similar pipe materials used in the service area.
- 5.12. Use of smooth interior, corrugated high density polyethylene pipe HDPE pipe is allowed for culverts but must follow proper manufacturer and pipe industry standards for flexible pipe design and installation including bedding, backfill, load and soil design. Appropriate reference to VDOT Road and Bridge Standards or specifications for pipe type and installation must be provided as intended use. If VDOT standards are not referenced, provide a typical bedding and installation detail, indicate type of pipe and minimum cover requirements during construction and allowable maximum height of final and temporary cover for the type of pipe selected. Use of corrugated smooth interior high density polyethylene pipe for private-drainage systems should have proper reference on the construction plan for pipe type (AASHTO M252, AASHTO M294, ASTM F667, etc.), bedding and installation in accordance with association standards (ASTM D2321, etc.) and for connection type to concrete manholes structures or inlets (ASTM C923, etc.)
- 5.13. Typical Mannings “n” values for culvert pipe types include 0.013 for Reinforced Concrete Pipe; 0.013 for Corrugated Steel Fully Asphalt Coated and Fully Paved; 0.013 for Corrugated Steel Fully Asphalt Coated and Fully Concrete Lined; 0.014 for Steel or Aluminum Smooth Wall Spiral Rib Pipe; 0.012 for High Density Corrugated Polyethylene Smooth Interior Pipe; and 0.011 for Polyvinyl Chloride Ribbed or Corrugated Smooth Interior Pipe.

- 5.14. Minimum and maximum heights of cover shall meet VDOT and manufacturer recommendations for the pipe type, strength, class, thickness or size. Adequate temporary protection or cover shall be provided during construction operations to prevent wall crushing and non-uniform deflection.
- 5.15. If required, improved inlets for culverts are acceptable if designed in accordance with current versions of the Federal Highway Administration, Hydraulic Engineering Circular No. 13, Hydraulic Design of Improved Inlets for Culverts and the VDOT Drainage Manual, as applicable. This includes beveled edged inlets, side tapered inlets and slope tapered inlets.
- 5.16. Minimum culvert size is 15 inch. Minimum culvert size across driveways, outside VDOT right-of-way is 12 inch.

**6.0 Outlet Protection or Energy Dissipator Design**

- 6.1. Erosion protection at storm drainage conveyance system outlets shall be provided in accordance with the Virginia Erosion and Sediment Control Handbook, Minimum Standard 3.18 and 3.19, for Outlet Protection and Riprap and current versions of the VDOT Drainage Manual and Road and Bridge Standards, as applicable. Outlet protection dimensions and depth, class and quantity of riprap and geotextile requirements shall be shown on the construction plans and details and design (sizing) computations shall be provided in the drainage report.
- 6.2. Outlet velocities in excess of eighteen (18) feet per second shall require use of special design energy dissipators, stilling or impact basins or if the receiving channel permissible velocities or space limitations are exceeded by use of standard riprap outlet protections. Designs shall include standard VDOT paved channels, paved flumes and EG-1 or 1A energy dissipators or other structures designed in accordance with FHWA, Hydraulic Engineering Circular (HEC) 14 for Hydraulic Design of Energy Dissipators for Culverts and Channels or other standard accepted references.

**7.0 Storm Drainage Easements**

- 7.1. Storm drainage easements, if required to be provided, shall be of sufficient width to provide the Owner with easy access to inspect, install, construct, reconstruct, operate, maintain or repair, any and all components of the drainage system.
- 7.2. Storm drainage easements, if required to be provided, shall be shown on the record plat and the stormwater management or drainage plan for the project.
- 7.3. In general, and at the discretion of the VESCP/VSMP administrator, no buildings or permanent structures shall be constructed within storm drainage easements. No trees, shrubs or woody vegetation or landscaping or permanently anchored structures, fences or obstacles shall be placed within a drainage easement which would render the easement inaccessible by vehicles, equipment or personnel.
- 7.4. In general, all facilities shall be located in the middle portion of the easement. Stormwater conveyance channel easements shall allow for sufficient width along one of the channel sides for vehicular access along the channel.
- 7.5. Consideration shall be given in selection of easement widths for potential upgrades or improvements that may be necessary in the future.
- 7.6. Storm drainage easements shall be provided in accordance with the following minimum width recommendations. Modification or adjustment to minimum required widths can be made on a case-by-case basis, depending on storm drain pipe size or channel geometry; however, in no case shall drainage easements be less than ten (10) feet in width.

7.6.A. Stormwater Conveyance Channels (Open Channels)

<u>Top Width of Channel</u>	<u>Minimum Easement Width</u>
Less than 2 feet	15 feet
2 to 5 feet	20 feet
5 to 10 feet	25 feet
Greater than 10 feet	15 feet greater than top width of channel.

7.6.B. Storm Drains

<u>Pipe Size</u>	<u>Minimum Easement Width</u>
18 inch or smaller	15 feet
21 - 33 inch	20 feet
36 - 48 inch	25 feet
54 - 72 inch	30 feet
Greater than 72 inch	Advance notification and approval necessary.

7.6.C. Deeper Installations. Consideration shall be given to easement widths provided for deeper storm drain installations. The minimum easement widths as outlined above may be inadequate for deeper excavation and burial situations unless shoring and bracing is utilized. In general, beginning at ten (10) feet in depth, an additional five (5) feet of easement width is recommended for each five (5) foot increment of additional depth.

**8.0 Post Installation Camera Inspection**

- 8.1. As part of the asbuilt/construction certification process for stormwater conveyance systems, post installation camera inspections shall be performed in accordance with the Chapter 8, Erosion and Sediment Control and Virginia Stormwater Management Program (VSMP) ordinance of the County Code, and in accordance with standards and specifications developed by the VESCP/VSMP authority administrator. Camera inspections shall not be required for pipe systems that are in their entirety less than 15-inch in diameter.
- 8.2. (Additional work is needed on this section to develop specifications and guidelines per Section 8-25 and 8-27 of Article II of the Chapter 8 ordinance. Standard industry references will be utilized.)

**9.0 Construction and Installation**

- 9.1. The Contractor shall keep the VESCP/VSMP authority notified of progress at all milestone stages of construction and/or if any unusual site or soil conditions are encountered during construction of storm drainage conveyance systems.
- 9.2. The Contractor is required to contact Miss Utility at 1-800-552-7001 and have existing utilities located prior to undertaking any excavations. This action does not relieve the Contractor of independent verification of existing utilities by hand excavation, test holes or other methods by their own forces.
- 9.3. The Contractor shall complete drainage facilities within thirty (30) days following the completion of rough grading at any point during the project. The installation of drainage facilities shall take precedence over all other underground utilities.
- 9.4. The Contractor shall not open or expose more than three hundred (300) linear feet of underground storm drain trench at any one time. Excavated material associated with these operations shall be placed on the uphill side of trenches. Following installation, all disturbed areas are to be stabilized immediately.

- 9.5. The Contractor shall attempt to schedule installation of storm drainage conveyance system during dry or periods of low flow to the greatest extent possible. Natural stream or base flow may require temporary diversion or pumping to adequate sediment control facilities.
- 9.6. The Contractor shall use laser technology to establish and set grade for stormwater drainage conveyance facilities on excessively flat slopes (generally less than 0.5 percent).
- 9.7. All soil stabilization blankets and matting shall be inspected periodically by the Contractor to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, reinstall material after repairing damage to the slope or channel and reseed. Installation of blankets and matting shall follow the requirements of the VESCH and applicable manufacturer recommendations.
- 9.8. For EC-3 or TRM stormwater conveyance channel linings, the Contractor shall apply and work lime into the soil prior to placement of soil stabilization fabric. Following fabric installation, lining voids shall be filled with topsoil and seeded and fertilized by permanent seed methods specified.
- 9.9. The Contractor shall immediately replace channel stabilization blankets and erosion control matting if site work or associated utility operations such as cable, electric, gas, phone, sewer, water, etc. damage their functional intent.
- 9.10. The Contractor shall provide temporary liners, such as polyethylene sheets, for all paved channels until permanent concrete liners are installed.
- 9.11. The Contractor shall install paved channels where design channel linings are inadequate and channel erosion is clearly evident, particularly in areas where slopes exceed three percent.
- 9.12. The Contractor shall provide inlet shaping for any access structures so designated on the plan in accordance with VDOT Standard IS-1. Inlet shaping shall consist of smooth flow transitions with accurately shaped arcs connecting the inlet and outlet pipes to prevent obstructions to flow. Changes in size and grade shall be made gradually and evenly.
- 9.13. The Contractor shall provide inlet protections in accordance with VESCH, Minimum Standard 3.07, as soon as practical following construction of the same.
- 9.14. The Contractor shall provide steps for access structures greater than 4 feet in depth in accordance with VDOT Standard ST-1. Steps shall consist of forged aluminum or steel encased in corrosion resistant, non-sparking, non-conductive material of acceptable design and durability. Steps shall be cast integrally with precast drainage structures and shall be constructed into and securely anchored to the walls of the structure, if cast-in-place. Steps shall be uniformly spaced 12 to 16 inches on center vertically and shall project evenly unless otherwise directed.
- 9.15. The Contractor shall provide intermediate safety landings in accordance with VDOT Standard SL-1, as specified for select and excessively deep access structures.
- 9.16. The Contractor shall be responsible for replacing with matching material any existing or proposed drains, pipes, culverts and drainage structures damaged due to handling, installation or lack of adequate temporary protection or cover during construction.
- 9.17. The Contractor shall be responsible for replacing with matching materials any existing pavement, driveways, walkways, curbs, etc. that must be cut or are in any way damaged during construction.

- 9.18. The Contractor shall clean storm drains and inlets of accumulated trash, debris and sediment at the last stage of construction.
- 9.19. The Contractor shall be responsible for implementing traffic and job site safety measures during construction activities; furnishing materials and workmanship that will result in drainage structures with suitable character and function; and recording details of construction necessary for inclusion into record drawing (as-built) or construction certifications as required by the Owner for the project.